1. For a SAR system, such as SIR-C, does the nominal 12.5 meter azimuthal resolution for the German X-band system correspond well to the nominal antenna width? What pulse length would be required to match that in range resolution?   Compare to the actual pulse width.

    $\text{Azimuthal Resolution} = \dfrac{L}{2} = \dfrac{12}{2} = 6 \text{ meters}$, which is about half the 12.5 meter

    azimuthal resolution they actually process to. (formula is for **scan** mode sar)

    $\text{Range Resolution} = \dfrac{ct}{2}$, or $t = \dfrac{2 \bullet 12.5}{3 \times 10^{8}} = 8.33 \times 10^{-8}$ seconds. The actual pulse is

    500 times longer.

2. What wavelengths and polarizations are used for the commercial SAR systems (Radarsat, ERS)?

3. For a spotlight mode SAR system, what azimuthal resolution could be obtained with x-band for a 10 second integration interval (assume v = 7 km/s, take the range (altitude) to be 500 km)

    $$\text{Azimuthal resolution} = \text{range} \bullet \frac{l}{\text{Effective antenna length}}$$

    $$= 500 \times 10^{3} \bullet \frac{3 \times 10^{-2}}{10s \bullet 7 \times 10^{3} \frac{km}{s}} = 0.214 \text{ meters}$$

4. For the conditions illustrated in Figure 8-12, the shuttle was at 222 km altitude, and the antenna (shuttle) attitude was 27.1°. What range does the $27.1^{\circ} \pm 3^{\circ}$ (measured from nadir) correspond to?

    Horizontal distance = altitude* tangent(incident angle)

Ground intercepts are at 98.81, 113.035, 128.045   km from the subsatellite point.   The range is 128.045 – 98.81 = 29.2 km

Chapter 8 − Problem 4
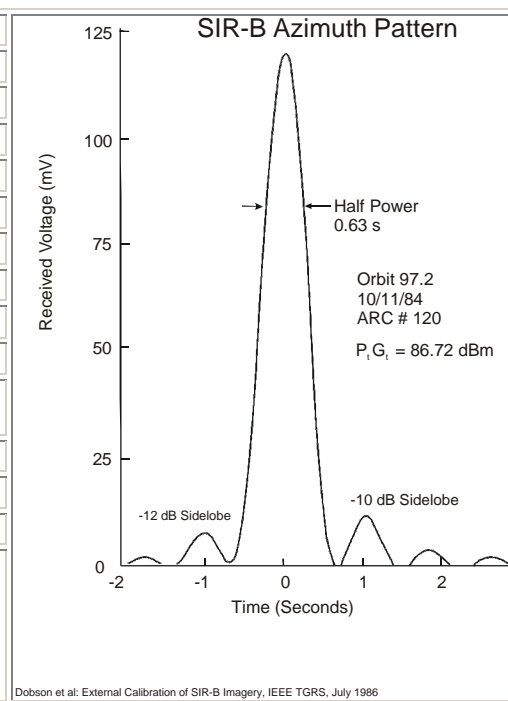
X-SAR Elevation Antenna Pattern
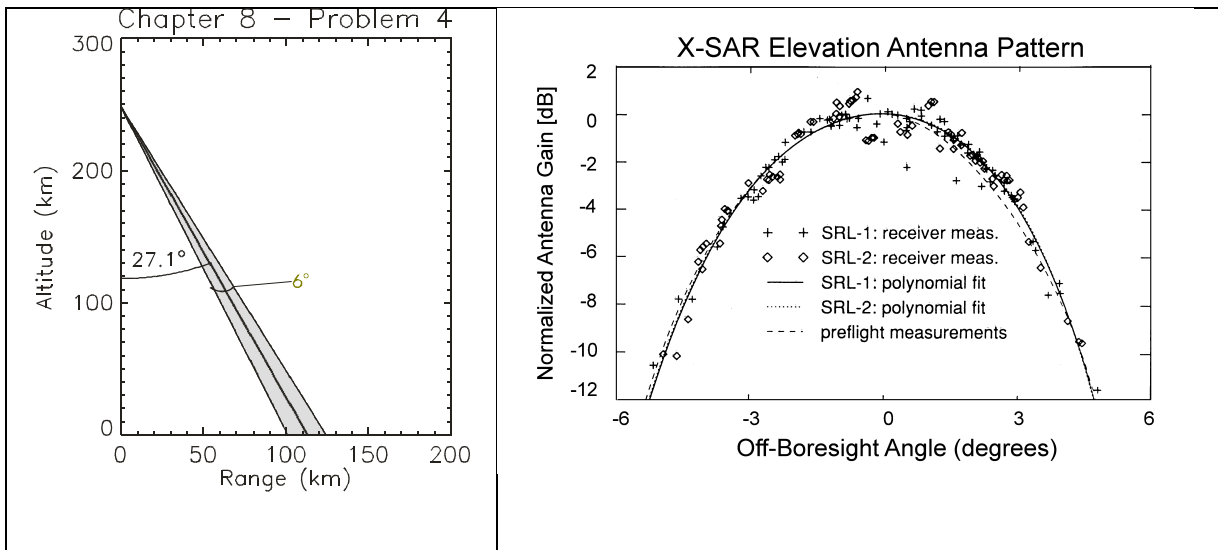
5. During an earlier shuttle flight (SIR-B), observations similar to those shown in Figures 8-10 to 8-12 were made. Given a vehicle velocity of 7.5 km/s, convert the variations in time displayed here into a beam width in degrees. The wavelength is 23.5 cm. The local angle of incidence is 31°. (The incidence angle is measured down from the vertical.) What is the antenna length implied by this antenna pattern?

SIR-B was launched on October 5, 1984 aboard the Space Shuttle Challenger on flight 41-G into a nominally circular orbit. **The average altitude** for the first 20 orbits was 360 km; for the next 29 orbits was 257 km; **and for the duration of the mission 224 km.** At the 224 km altitude, the orbit was allowed to drift slightly westward with an approximate 1- day repeat cycle. This enabled SIR-B to image a given site at several different incidence angles on subsequent days over the course of the mission.

SIR-B Mission Parameters

Shuttle Orbital Altitudes	360, 257, 224 km
Shuttle Orbital Inclination	57 degrees
Mission Length	8.3 days
Radar Frequency	1.275 GHz (L-band)
Radar Wavelength	23.5 cm
System Bandwidth	12 MHz
Range Resolution	58 to 16 m
Azimuth Resolution	20 to 30 m (4-look)
Swath Width	20 to 40 km
Antenna Dimensions	10.7 m x 2.16 m
Antenna Look Angle	15 to 65 degrees from vertical
Polarization	HH
Transmitted Pulse Length	30.4 microseconds
Minimum peak power	1.12 kW
Data recorder bit rate (on the ground)	30.4 Mbits/s

SIR-B Azimuth Pattern

Received Voltage (mV)

Half Power 0.63 s

Orbit 97.2
10/11/84
ARC # 120

$P_t G_t$ = 86.72 dBm

-12 dB Sidelobe

-10 dB Sidelobe

Time (Seconds)

Dobson et al: External Calibration of SIR-B Imagery, IEEE TGRS, July 1986

Slant Range = 224 km/cosine(31°)=259 km
I take the zero-to-zero time to be about 1.3 seconds, or a ground distance of 9.75 km. The distance from the center line to one null is half that, or about 5 km.

These numbers give an angular range of $\Delta q = \dfrac{5 \text{ km}}{259 \text{ km}} = 1.93 \times 10^{-2}$ radians

These zeros correspond to the places where $\dfrac{kL\sin q}{2} = p$, or $\dfrac{2p L \sin q}{2l} = p$, or $\sin q = \dfrac{l}{L}$

$\sin q = \dfrac{l}{L} = \dfrac{0.235}{10.7} = 2.2 \times 10^{-2}$, or $\Delta q \approx 2.2 \times 10^{-2}$ radians

6. The decrease in radar energy as the beam propagates is illustrated by an example from the SIR-B mission, which shows the results of measuring the variation in power observed at depths of 12 and 35 cm in desert soil (near Mina, NV), from a paper by Farr et al. 1986. If the radar energy has decreased by 8 dB in the first 12 cm, what is the characteristic scale length, d, as defined here? This scale length is determined by the imaginary part of the dielectric coefficient.

$$I = I_o \; e^{-x/d}$$

missing figure – ignore this problem

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